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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE

GEOLOGY

OF THE COUNTRY BETWEEN

NORHAM AND TWEEDMOUTH IN NORTHUMBERLAND.

(EXPLANATION OF QUARTER-SHEET 110 N.W.,
NEW SERIES, SHEET 1.)

BY

W. GUNN, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.



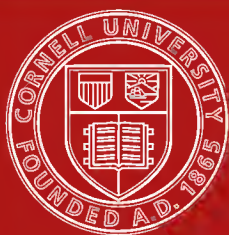
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PREFACE.

THE area described in the following pages occupies a small triangular space of about 23 square miles, on the northern border of Northumberland, between Norham and Tweedmouth, which is contained in Sheet 110 of the Geological Survey Map of England and Wales. It was surveyed in the year 1880 by Mr. W. Gunn, under the supervision of Mr. H. H. Howell, at that time District Surveyor in the Geological Survey of England and Wales. The Map was published in 1884, and the present Explanation was written at that time, but from various causes its publication has been kept back until now.

The geology of the area is extremely simple, the rocks consisting entirely of stratified formations, belonging to the Carboniferous Limestone Series, and chiefly to that portion of this series which is represented by the Scar Limestone of Yorkshire. The Cement Stones, Fell Sandstones, Scremerston Coals, and Marine Limestones follow each other in regular succession, having a south-easterly dip, and striking north-eastward nearly parallel with the general course of the River Tweed. The Six-inch Maps of Northumberland, representing the area described in this Explanation, are Nos. 3, 5, 6, and small parts of Nos. 4 and 7. MS. copies of these maps are deposited in this Office for reference.

ARCH. GEIKIE,
Director-General.

Geological Survey Office,
28, Jermyn Street,
London, S.W.
6th April 1897.

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THE GEOLOGY OF THE COUNTRY BETWEEN NORHAM AND TWEEDMOUTH IN NORTHUMBERLAND.

CHAPTER I. INTRODUCTION.

PHYSICAL FEATURES.

The area to be described in this memoir is a small portion of the northern part of Northumberland bordering the southern bank of the River Tweed from Tweedmouth to beyond Norham. Part of it drains into the Tweed by small burns such as those of Newbiggin, Norham Mill, and Velvet Hall, while the south-eastern part is drained direct into the North Sea by Allerdean Burn and its tributaries, such as Coal Burn. The watershed runs northward from New Winning to Thornton Bog and Longridge, and then turns eastward to Billylaw. The ground is low and undulating, the highest point being near Billylaw, 357 feet above the sea, to the westward of which is the only area of any size upwards of 300 feet in elevation. There are small tracts at Shoreswood Hall and west of Shoreswood just over 300 feet.

More than half the length of the Tweed in the area is tidal, ordinary spring-tides ascending to the island above Horncliffe; but as the banks of the river are high, very little of the ground is below the 100-foot contour-line, except the alluvial terraces and great part of the strip of ground north of the railway and east of Loan End.

GEOLOGICAL DESCRIPTION.

The rocks comprised in this area are entirely sedimentary and, with the exception of the Superficial Deposits, they belong wholly to the Carboniferous Limestone Series. These have a generally steady dip to the south-eastward, so that we find the highest beds in that region and the lowest along the Tweed. Roughly, we may describe the ground as made up of four strips parallel to one another: the highest having fairly thick beds of limestone; the next being characterised by many coal-seams; the third being made up almost entirely of thick sandstones; and the fourth consisting of alternations of sandstones and shales with thin, impure, pale-coloured limestones or cement-stones. These four sets of beds strike in succession across the country from south-west to north-east, but none of them as a rule form prominent features by which they can be traced, save to some extent the thick sandstones between East Ord and Longridge. All the

more prominent features—those of hill and valley—run nearly east and west, or from east-south-east to west-north-west, so that the coal-crops can only be traced by means of the old workings, and the limestone-beds by the sections in old quarries and in a few streams; for in this low ground no shake-holes or swallow-holes have been formed in the limestone. Over the greater part of the area the Carboniferous rocks are masked by Boulder Clay.

TABLE OF FORMATIONS.

Post-Glacial	{	Alluvium and River Terraces.
	{	Peat Bogs and Old Lake Deposits.
Glacial	{	Sand and Gravel.
	{	Boulder Clay.
Carboniferous	{	Limestone Group or Calcareous Division.
Limestone	{	Scremerston Coal Group or Carbonaceous
Series.	{	Division.
	{	Fell Sandstone Group.
	{	Cement Stone Group or Tuedian.

CHAPTER II. CARBONIFEROUS.

CEMENT-STONE GROUP, OR TUEDIAN.

These beds are well exposed in various places along the banks of the Tweed and are also to be seen in Horncliffe Dean and Newbiggin Dean. They consist of reddish and white sandstones alternating with thick masses of reddish, green, grey, chocolate, and dark shales containing thin bands of impure limestones or cement-stones. By the fossils they contain they are considered to be mainly of freshwater origin, but they include in places bands of marine limestone. About 1,200 feet of these beds are exposed in this area without getting nearly to the bottom of the series, lower beds being seen further up the Tweed.

The beds seen along the Tweed in the south-western part of the district dip N.E. and consist of shales, sandstones and cement-stones with a 15-inch band of yellow magnesian (?) limestone. At Groathough Quarry near by, thick-bedded greyish sandstone has been quarried. Before reaching the Lover's Walk the beds have a south-easterly dip. About West Newbiggin the beds have no regular dip. Close to the foot of the dean there is a whitish sandstone which has many lenticular coal-patches in it, and there is reddish shale below. A little way up the dean on the south side, there is a fine section in shale with many cement-bands, and this overlies the above-mentioned sandstone. Northward along the river-side towards Norham, there are 70 to 80 feet of shales and sandstone, with cement-beds, capped by a sandstone. This dips northward at 12° into a synclinal which may be broken by a fault, but the section was obscure.

The beds rising to the north consist as follows:—

Grey and reddish, or dark, clayey shale with cement-stones.
Thick irregular white sandstones.

These last can be followed to the boat-house where shale is seen below.

There is a quarry at Galagate by the road-side east of the village, in reddish and whitish soft irregular micaceous sandstone, dipping S.E. 8° , and capped by grey and yellow clayey marl. Up the Mill Burn alternations of these beds are seen dipping steadily to S. or S.E., at angles of 10° to 12° , and there is a fine section by the river-side northward from Norham Castle where the beds dip S.S.E. at 10° . We see here the following strata:—

Shales beautifully banded with many cement-stones, 15 to 20 feet.

Thick reddish sandstones, 30 to 35 feet.

Shales, grey reddish and chocolate, banded with cement-beds and thin sandstone, and an irregular bed which thickens northward; about 50 feet.

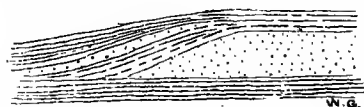
It is possible that these rocks are the same as those seen at the foot of Newbiggin Dean. South of the Red Rock (a cliff of red sandstone with shale and sandstone above), there may be a fault,

but the masses of sandstone are so changeable in character and thickness that it is not safe to put in a fault unless one is actually seen. North of the Red Rock the dip increases to 20° or 25° , and beyond the little stream which enters here, there is a very interesting section. Below thick soft sandstone weathering into rounded forms, and which is reddish and false-bedded, we find the following series :—

		In.	Ln.
Variegated, red, grey, and purple rocks.	Concretionary-looking breccia with plant-stems	0	to 12
	Wedge-bedded shale and sandstone, some layers brecciated	6	to 15
	Calcareous breccia containing fish- teeth and calcified rootlets	0	to 4
	Reddish brecciated shale	2	to 3
	Yellowish limestone in bands, with Corals	0	to 12

In Horncliffe Dean many alternations of rock are seen dipping steadily S.S.E. to S.E. at angles of 8° to 10° , but in one place at an angle as high as 20° . Above the mill there is a whitish sandstone, irregular below, and reddish in places, having a greenish breccia at the base, and 1 to 2 feet of ferruginous mud-stone below. West of Horncliffe the beds dip from S. to S.S.E. at 15° to 20° , and there is a good section in the quarry, with shales and cement-stones above white sandstone passing down into red sandstone. The beds are also well seen from Horncliffe House to the Chain Bridge (Union Bridge on map). Thick-bedded sandstones with some laminated sandstones alternate with red and grey shales, banded with cement-beds. Near the Chain Bridge there is a synclinal, the beds dipping N.N.W. and then S.S.E., and, according to Winch, a small fault was formerly visible here having a throw of 6 feet. We again get good sections between West Ord and Upper Yarrow Shiel where the dip is about 15° steadily to the S.S.E., in grey, green, and chocolate shales with cement-stones, alternating with red and white sandstones. These last are very irregular in places, as below the old Camp near the mouth of the Whitadder and west of Ord Burn. (See Fig.)

Shales.
Sandstone,
Sandy shale.



False-bedding west of Ord Burn, banks of the Tweed.

CHAPTER III. CARBONIFEROUS—(*continued*).

FELL SANDSTONE GROUP, OR LONGRIDGE SANDSTONE.

These beds were included by George Tate in his Tuedian Series, but they may conveniently be described by themselves as they generally form a marked feature between the coals above and the cement-stone series below. The base of the series has not been drawn on the map, but roughly it may be taken to coincide with the road running from the north-west end of Tweedmouth, past Velvet Hall and Salutation Hall, and thence striking across country to Grindon. This mass of sandstones is estimated to be 600 feet thick or more, with very little shale. Some purple and grey shales with cement-stone nodules were noticed in the stream west of the village of East Ord, and these should be in the middle of the mass. Generally the sandstones are massive and not very coarse, the prevailing tint being light red, but white and brown sandstones are not rare. There are several marked scars of sandstone between Murton and Longridge, *e.g.*, Murton Scar and Murton Dean. South of Thornton Bog the sandstone is not so prominent, partly owing to the covering of drift and partly to the softer nature of the stone. West of Grievestead it is soft and rather coarse in places and has been dug for sand. There are sections in the burn between Grievestead and Salutation Hall where for some distance the beds seem to dip westward, but there is a good deal of false-bedding. At Salutation Hall there is a quarry in massive white and brown stone, the beds being a good deal crushed at top. At the west end of Shoreswood is a large quarry in massive reddish and whitish stone with marked joints in two sets ranging S.W. and N. 40° W., and there are also quarries near Newburn and Thornton Cottage, and south of Thornton.

North of Murton and south-west of Gamesgreen Plantation a thin coal is seen with an underclay. Northward from Gamesgreen Plantation there is a large quarry in massive light-red sandstone of which 30 feet is seen, with two sets of joints running W.N.W. and N. 35° E. On the south side of East Ord we find another large quarry, nearly 50 feet deep, in massive whitish sandstone; and at the junction of roads further east, near the Manse, is a third large quarry showing the following section:—

	Ft. Ft.
Sandstone mostly thick-bedded, broken above, with some thin beds below	8 to 10
Reddish clayey shale, passing up into a kind of fire-clay	7 to 8
Sandstone white and grey, also yellowish and pinkish, thick-bedded, upper 6 to 7 feet fine and white, but coarser towards the bottom	30
Dip S.S.E. 10°-15°.	

The thick sandstones of this group have generally been called Fell Sandstones in the country to the south, and along the Scottish Borders.

CHAPTER IV. CARBONIFEROUS—(continued).

SCREMERSTON COAL GROUP, OR CARBONACEOUS DIVISION.*

This series is about 900 feet thick, and consists of alternations of sandstones and shales with thin limestones, and many coals and fire-clays. It ranges from the Dun Limestone down to the Wester Coal, the lowest of the series that has been worked. We are not able to give details of the whole of these beds from actual sinkings within the area, as though nearly all the beds have been proved, many of the workings are very old, and sections could not be obtained. In the sinking at Jack Tar Pit, Scremerston, in the district to the east, the section below the Dun Limestone may be summarised as follows:—

	Ft.	In.
Dun Limestone - - - - -	7	0
Coal - - - - -	1	2
Measures, mostly freestone - - - - -	135	0
Roby's Coal - - - - -	1	5
Measures - - - - -	78	0
Caldside Coal, or Fawcett Seam (here unusually thin) - - - - -	0	8
Measures, including 25 thin coals - - - - -	310	0
Scremerston Main Coal - - - - -	4	4

The Fawcett Seam was once worked east of Unthank, where there are several old shafts, and it must be here 50 fathoms or so above the Scremerston Main Coal, which was worked at Unthank Colliery at a depth of 48 fathoms. The usual thickness of the Caldside or Fawcett Seam is from 2 feet to 2 feet 6 inches. The Roby's Coal has not, so far as we know, been worked within this area. Below the Scremerston Main Coal, five or six different seams have been worked down to the Wester Coal. We give below the section of Felkington Old Pit, sunk about the year 1859. It is on Felkington North Moor, on the north side of a fault which throws down in the same direction 84 feet.

Section of Felkington Old Pit.

	Ft.	In.	Ft.	In.
1. Soil and Clay - - - - -	9	0		
2. Freestone bands - - - - -	5	0		
3. Red Sandstone - - - - -	36	0		
4. Blue Metal - - - - -	2	5		
5. Coal - - - - -	0	9		
6. Hard bastard limestone - - - - -	2	6		
7. Coal - - - - -	1	0		
8. Blue Metal - - - - -	2	10		
9. Limestone - - - - -	2	7		
10. Blue Metal - - - - -	2	10		
11. Top Coal 2 ft. 6 in. {	SCREMERSTON MAIN COAL or BLACKHILL SEAM. }			
12. Band Stone 2 in. {				
13. Ground Coal 10 in. {				
	3	6		

— 68 5

* In the description of the Scremerston Coals I have to acknowledge my indebtedness to Mr. R. Nesbitt, Manager of the Scremerston Coal Company, and to Mr. G. Bailes, former Manager.

						Ft.	In.	Ft.	In.
14.	Soft blue Metal	-	-	-	-	2	0		
15.	Limestone	-	-	-	-	0	3		
16.	Strong grey tills	-	-	-	-	2	0		
17.	Freestone	-	-	-	-	1	8		
18.	Metal	-	-	-	-	0	2		
19.	Coal	-	-	9 in.	HARDY OR STONY COAL SEAM.	4	7		
20.	Band. Blue Metal	-	-	9 in.					
21.	Coal	-	-	1 ft. 2 in.					
22.	Band. Limestone	-	-	1 ft. 2 in.					
23.	Coal	-	-	9 in.				10	8
24.	Strong tills mixed with freestone	-	-	-	-	1	2		
25.	Grey tills	-	-	-	-	1	0		
26.	Coal	-	-	-	-	1	4		
27.	Tills	-	-	-	-	2	0		
28.	Freestone bands	-	-	-	-	4	0		
29.	Limestone	-	-	-	-	1	6		
30.	Coal	-	-	-	-	0	4		
31.	Tills	-	-	-	-	2	6		
32.	Blue Metal	-	-	-	-	17	0		
33.	Freestone bands	-	-	-	-	6	3		
34.	Blue Metal	-	-	-	-	10	0		
35.	Coal	-	-	-	-	0	3		
36.	Freestone bands	-	-	-	-	1	0		
37.	Top Coal	-	-	1 ft. 2 in.	MAIN COAL OR BULMAN SEAM.	6	7		
38.	Chalk stone	-	-	1 in.					
39.	Splint Coal	-	-	1 ft. 1 in.					
40.	Rough Coal	-	-	7 in.					
41.	Band. Grey Metal	-	-	1 ft. 8 in.					
42.	Parrot Coal	-	-	8 in.					
43.	Ground Coal, Parrot	-	-	11 in.					
44.	Chalk stone	-	-	1 in.					
45.	Smithy Coal	-	-	4 in.				54	11
46.	Strong grey tills	-	-	-	-	0	7		
47.	Soft light-blue Metal	-	-	-	-	0	9		
48.	Freestone bands	-	-	-	-	0	6		
49.	Metal	-	-	-	-	0	3		
50.	Limestone	-	-	-	-	1	1		
51.	Black Metal	-	-	-	-	0	10		
52.	Limestone	-	-	-	-	0	3		
53.	Coal	-	-	-	-	0	11		
54.	Limestone	-	-	-	-	0	11		
55.	Coal	-	-	-	-	0	7		
56.	Strong tills	-	-	-	-	4	6		
57.	Soft blue Metal	-	-	-	-	1	11		
58.	Tills	-	-	-	-	2	6		
59.	Strong grey tills	-	-	-	-	18	0		
60.	Freestone bands	-	-	-	-	38	0		
61.	Blue Metal	-	-	-	-	5	0		
62.	Grey freestone	-	-	-	-	8	0		
63.	Coal	-	-	-	-	0	6		
64.	Hard red freestone. Ten Quarter Stone	-	-	-	-	18	0		
65.	Blue Metal	-	-	-	-	2	0		
66.	Grey freestone. Ten Quarter Stone	-	-	-	-	15	0		
67.	Blue Metal	-	-	-	-	12	0		
68.	Limestone	-	-	-	-	2	0		
69.	Coal	-	-	-	-	1	0		
70.	Metal	-	-	-	-	0	6		
71.	Grey tills	-	-	-	-	2	0		
72.	Coal	-	-	1 ft. 2 in.	THREE QUARTER COAL.	2	8		
73.	Band stone	-	-	6 in.					
74.	Coal	-	-	1 ft. 0 in.					

formerly much wrought at Shoreswood Colliery, south of Shoreswood Hall, at a depth of 43 fathoms, where the section was as follows :—

						Ft.	In.
Limestone, roof of seam	-	-	-	-	-	1	0
Top Coal	-	1 ft. 4 in.	}	-	-	-	-
Grey stone band	-	9 in.	}	-	-	3	3½
Ground Coal	-	1 ft. 2½ in.	}	-	-	-	-

This is very similar to the Felkington section given above.

The only place in the area where it was (in 1885) being worked, was Billylaw Colliery, and there it had been reached at a depth of 26 fathoms. There was the usual limestone roof, 1 foot 3 inches in thickness, and the section of the coal was as follows :—

						Ft.	In.	Ft.	In.
Coal (splint)	-	-	-	-	-	-	1	5	
Midstone	-	-	-	-	-	-	2	0	
Ground coal	-	-	-	-	-	-	1	1	
									4 6

At Murton Colliery the section of the Cooper Eye is said to have been :—

							Ft.	In.
Splint Coal	-	-	-	-	-	-	1	2
Metal	-	-	-	-	-	-	0	1½
Stone	-	-	-	-	-	-	1	1
Ground Coal	-	-	-	-	-	-	1	0½

The *Three Quarter Coal* comes from 10 to 15 feet above the Cooper Eye, and therefore will have practically the same outcrop on the map as that seam. It seems to have been little worked in this area, being a poor seam or series of seams with several bands. We give below the sections of this seam at Felkington, Shoreswood, and Billylaw :—

<i>Felkington.</i>			<i>Shoreswood.</i>			<i>Billylaw.</i>		
	Ft.	In.		Ft.	In.		Ft.	In.
Limestone	2	0	Limestone	1	11	Limestone	1	1
Coal	1	0	Coal	1	0	Coal	0	9
Metal	0	6	Soft grey stone	0	4	Macker	0	4
Grey tills	2	0	Coal	0	8	Coal	0	7
Coal	1	2	Metal	0	5	Brassy band	0	1
Band stone	0	6	Grey stone	2	1	Coal	0	6
Coal	1	0	Coal	2	1	Limestone bands	0	6
						Coal	0	6

In the Felkington section the two lower coals are called the *Three Quarter*, while in the Shoreswood section the name is restricted to the seam at the bottom ; and at Billylaw the name is applied to the whole series below the limestone.

Some distance above this seam comes occasionally a marked freestone-band called the Ten Quarter Stone. This bed forms the highest ground at Billylaw and has been quarried east of the main road near South Ord ; but very often these freestones are so soft that they can be dug for sand. A thin yellow limestone may be seen on Bleak Ridge, north-west of the old pit called New Winning.

The *Bulman* or *Cancer Coal* is found to be usually from 20 to 25 fathoms above the Cooper Eye, but it must be more than 26 fathoms at Billylaw.

The sections of this seam at Shoreswood and Felkington Old Pit are as follows :—

<i>Shoreswood.</i>			<i>Felkington Old Pit.</i>		
	Ft.	In.		Ft.	In.
Top Coal	-	1 4	Top Coal	-	1 2
Chalk Stone	-	0 1	Chalk Stone	-	0 1
Splint Coal	-	1 10	Splint Coal	-	1 1
			Rough Coal	-	0 7
Grey stone band		1 4	Band, grey Metal	-	1 8
Ground Coal	-	0 8	Parrot Coal	-	0 8
			Ground Coal, Parrot		0 11
Chalk Stone	-	0 1	Chalk Stone	-	0 1
Smithy Coal	-	0 11	Smithy Coal	-	0 4

In a pit at Murton Colliery $18\frac{1}{2}$ fathoms deep, which was working in 1820, the section of the *Bulman Main Coal* was as follows :—

	Ft.	In.
Top Coal	-	1 3
Chalk Stone	-	0 1
Splint Coal	-	1 $0\frac{1}{2}$
Rough Coal	-	0 6
Stone	-	0 5
Ground Coal	-	1 $4\frac{1}{2}$
Chalk Stone	-	0 $1\frac{1}{2}$
Smithy Coal	-	0 9

The coal here is about 20 fathoms below the Scremerston Main Coal. The *Bulman Coal* was sunk for in the last Engine Shaft at Unthank, but was not in existence, according to Mr. Bailes (formerly Manager of the Scremerston Collieries), who thinks the workings in the *Bulman* further east were stopped owing to the seam thinning out.

In 1885 the *Bulman Coal* was being worked in a new pit at Felkington, just south of the limits of the area, at a depth of 19 fathoms. The Top Coal is usually left on for a roof. From Shoreswood and Felkington southwards this coal is called the *Main Coal*, while the Scremerston Main Coal is called the *Blackhill Seam*. It seems to have been wrought nearly everywhere at the outcrop, except perhaps near Billylaw, but never to so large an extent as the Cooper Eye Seam.

The *Hardy* or *Stony Coal* is a poor seam occurring a few feet below the Scremerston Main Coal. It appears to have been little wrought in this district. Reference may be made to it in the section of Felkington Old Pit. Where it has been wrought, its outcrop, as shown on the map, will virtually be the same as that of the coal above. The pits near the Folly, West Allerdean, are said to have worked a seam called the *Diamond Seam*, which comes just below the Hardy Coal; it appears to have been a poor coal.

The *Scremerston Main Coal* or *Blackhill Seam* is usually found to be 10 or 12 fathoms above the *Bulman* or *Main Coal*. The section at *Felkington* is as follows:—

<i>Felkington Old Pit.</i>		<i>Felkington New Pit.</i>	
	Ft. In.		Ft. In.
Top Coal -	- 2 6	Top Coal -	- 2 0
Band stone - -	- 0 2	Band stone - -	- 0 2
Ground Coal -	- 0 10	Ground Coal -	- 0 8

This seam has been but little worked on *Felkington Moor*, and it has not been proved at *Shoreswood Colliery*, where 22 fathoms of beds were sunk through above the *Bulman Seam* without any coal, more than 18 fathoms of this thickness being freestone. Whether the coal exist to the south-east of the shaft, or has been nipped out by the thickening of sandstone cannot be said; but there is no thick sandstone above the *Bulman* in either of the *Felkington Pits*, and the thick sandstones which do occur there (6 fathoms in one and 9 fathoms in the other) come above the *Scremerston Main Coal*. Much doubt exists as to the seam which was worked at the pit by the road-side between *West* and *East Allerdean*, but all accounts seem to agree that it was not the *Scremerston Main Coal*, which thus appears to have been wrought very little south of *Allerdean*. There is one pit where this coal was reached at about 20 fathoms, nearly 200 yards south-east of the *Miller's Bridge*. North of *Allerdean* the seam has been extensively wrought, and *Unthank Moor* is quite riddled with shallow old pits—the deepest of which at *Unthank Colliery* was 48 (or 40) fathoms. The outcrop for a long way keeps near the main road, and about 100 yards south of the *Miller's Bridge*, a coal with an underclay is seen on the west side of the road. So far as we know this is the only place where any of the coal-seams above described can be seen to crop out, and the outcrops marked on the map have had to be inferred from old plans and workings.

The coals are all more or less bituminous and the better sorts make a fairly good household coal, which at one time had an extensive land-sale on the borders. The coal was mainly drained in old times by means of levels driven in from the nearest low ground. There is a very old level traceable by means of old shafts near *Thornton*, which was made to drain the rise pits on the north side of *Shoreswood*, but the two most important of these old levels drain into *Allerdean Burn*. The one north-east of *Thornton Mains* drains all the old rise pits to beyond *Felkington*, outside the southern limit of the map, and the level near *Allerdean Mill* "unwatered" many of the old pits on *Unthank Moor*.

CHAPTER V. CARBONIFEROUS—(continued).

LIMESTONE GROUP, OR CALCAREOUS DIVISION.

This is a set of beds ranging upwards from the Dun Limestone, in which occur limestones of considerable thickness. We will first give an estimate of the general section of these beds in this area, and afterwards mention the few places where they may be seen. The sequence is as follows :—

	Ft.	In.
Sandstone and shale	-	100 0
OXFORD LIMESTONE	-	20 0
Sandstone and shale with coal	-	50 0
Limestone (thin)	-	
Greenses Coal	-	2 6
Sandstone and shale	-	} 220 0
Muckle Howgate Coal	-	
Sandstone and shale with, probably, thin limestone	-	90 0
Oil shale	-	
Sandstone and Shale	-	85 0
Little Howgate Coal	-	3 0
Sandstone and shale	-	60 0
WOODEND LIMESTONE	-	10 0
Sandstone and shale	-	100 0
DUN LIMESTONE	-	5 ft. to 6 0
Coal	-	1 ft. to 1 6

These thicknesses, except in the case of the limestones and the coals, must be considered only as approximations, no good section existing in this area. The Dun Limestone Coal has been proved by the side of the burn south of East Allerdean, and the limestone can be seen in the burn. A coal 18 inches thick is said to have been proved near Allerdean Mill, which is probably this coal.

The *Dun Limestone* is generally of a brown colour, hence its name, and it has been very little quarried in this area. Some beds of sandy shale and thin sandstone that come between the Dun and the Woodend Limestones, crop out at Allerdean Mill, dipping S.E., 15° to 20°.

The *Woodend Limestone* was formerly quarried in Reekyrow Plantation, near East Allerdean, and is said to have been 14 feet thick. It may be seen in the wood east of Allerdean Mill, where it is at least 7 feet thick and probably more, and again at Slateford, where the road crosses the Howgate Burn. It is generally a light-coloured limestone, often nearly white, rubbly and shaly above with numerous fossils, principally small Corals. There is an old quarry west of the Slateford Burn which is probably in the Woodend Limestone, and another 250 yards further west which may have been in the Dun Limestone.

Some of the sandstones and shales that come between the Woodend and the Oxford Limestones may be seen in quarries, in the banks of Allerdean, and in the burns further south. The Little Howgate Coal has been worked near the head of the Coal Burn to some extent. It was largely wrought near the east

edge of the area more than a hundred years ago, the workings being drained by means of a level driven from the Slateford Burn. The seam is said to have been 3 feet thick and wrought for lime-burning—dip from information, 1 in 5.

The bed of oil-shale seems a persistent one, for it can be recognised in several widely distant places on or about the same horizon. It may be seen in the burn S.E. of East Allerdean where it is contorted, and beds near it are dipping at angles of 30° to 50° to S.S.E., probably due to a fault close by. It has also been proved in a field east of the limestone-quarry in Reekyrow Plantation.* It seems to be of good quality, but too thin to be of use. Remains of Fishes, Plants, and Ostracoda have been found in it.

The *Muckle Howgate Coal* appears not to have been worked in this area.

The *Greenses Coal* takes its name from Ancroft Greens or "The Greenses," near which the coal has been worked, principally for lime-burning. It seems also to have been wrought for the same purpose at the lime-works near Ancroft North Farm in shallow pits; and it was sunk to and worked at the eastern edge of the district near Longdyke, at a depth of 24 fathoms. It was said to be here about 60 feet below the Oxford Limestone and had a 2-foot limestone for roof, the coal being 2 ft. 6 in. thick.

The beds between the coal and the Oxford Limestone consist mainly of freestone-bands, but about 8 feet below the limestone occurs a thin coal of 10 inches, which may be seen in the stream about 100 yards east of Greens Bridge, having shale above and an underclay below.

The Oxford Limestone, from 18 to 20 feet thick, has probably been more extensively quarried in north Northumberland than any other limestone. Large and deep old quarries in this limestone occur in many places, but as they are usually full of water, like those near Ancroft North Farm, they afford no sections. The limestone usually has a very thick bed of shale over it, some 50 or 60 feet thick, and the lower 20 to 30 feet of this may be seen over the limestone at the Greenses Quarry. The limestone is blue, shelly and encrinital, but the lower parts are unfit for lime-burning. It does not seem to occur in this area on the south side of the large fault which ranges from Felkington Old Pit to near Longdyke, except in one doubtful place east of the Long Loaning Plantation. A coal 1 foot thick is visible north of the east end of this plantation, and sandstones are seen down the burn; but these, and the sandstone dipping N.N.W. a long way to the east, are probably below the limestone. The shales that come above the limestone crop out near the Mill Pond on the north side of the fault, and the limestone has been largely quarried on the north side of the burn just outside the district under consideration.

* The late Dr. Paxton, of Norham, kindly pointed out the place to me.

CHAPTER VI. FAULTS.

The Felkington fault is the largest one proved within the area. At the Felkington Old Colliery it had a throw of 84 feet down to the north, but at New Winning the throw was only 42 feet. The small faults on the south side of it have been proved in the workings. The throw of 18 feet north of Shoreswood is said to have been proved in mining, and near Shoreswood Hall and the Folly, a "trouble" is described as occurring, but some accounts make it doubtful whether there is an actual break or only a thinning out or "*nithering*" of the coal.* There is however disturbance in the burn south of East Allerdean, and the Oxford Limestone appears to be shifted as if by a downthrow to the north.

There is a large fault in Aller Dean which throws down to the south-west, for the line of outcrop of the Oxford Limestone is shifted about 500 yards just at the edge of the map. It seems to die out westwards, however, and cannot be traced through the coals, unless the small downthrow of 5 feet proved in the Cooper Eye Workings north-west of the Miller's Bridge be a continuation of it. The fault near the edge of the area north-east of Unthank has a downthrow on the north-east of 96 feet a little way to the east, and the workings in the Scremerston Main Coal, at Unthank, were stopped by it; but it must be rapidly losing its throw westward. Possibly it is connected with the fault having a northerly downthrow of 6 feet near Murton Square.

* Some examples of this thinning of coal-seams are mentioned by Mr. Boyd in his paper in the *North of Engl. Inst. Min. Eng.*, Vol. ix., p. 190. One occurs in the Shoreswood workings.

CHAPTER VII. GLACIAL AND POST-GLACIAL DEPOSITS.

GLACIAL DRIFT.

A large part of the areas occupied by the Limestone group and the Scremerston Coal Series seems to be covered by Glacial Clay which is not very thick, and is very difficult to map, so that the boundaries drawn are only approximately correct. No doubt in some parts there is little or no drift where it has been coloured as such, and drift areas exist in parts where none has been mapped. The clay is generally grey with often a reddish tinge. It was 9 feet thick at Felkington Colliery. Over the cement-stone area of the Tweed valley the Glacial clay is thicker and generally widespread, and is of a more decidedly red tint, especially as we approach the sea-coast.

Over the area between Longridge and Norham the drift is disposed in the form of long ridges or drumlins with intervening hollows, which mostly run nearly east and west, the prevailing direction being a little north of east. These ridges seem, so far as one can judge, to be composed of a gravelly kind of clay, the materials being more loosely aggregated than in the flatter areas; and the boulders they contain are generally well rounded. Throughout the district where drumlins occur, well-rounded boulders of Silurian grit or grauwacke are very numerous at the surface, together with boulders of Cheviot porphyrite, quartzite, &c.

There are very few sections. There must have been many along the railway at one time, in some places 20 to 25 feet deep, as near East Ord; but the banks are now grassed over. A boring for water near Norham proved 13 feet 6 inches of marl, clay, and sandy clay. Near Tweedmouth the clay has been used for brick- and tile-making. There is a section in the clay-pit west of the railway near Millhouse which shows 15 feet or more of clay mostly of a light red or chocolate-colour with some sand. About 6 feet from the top the clay is laminated and rather sandy. On the north side of the pit a lighter-coloured clay is seen below, and this is laminated and without stones. A reddish clay is also seen in the old clay-pit east of Tweedmouth Grove, which was once a tile-yard. There are a good many places in the area where small patches of Glacial sand and gravel occur. Sometimes these seem to be thin bands in the Glacial clay, but usually they overlie it and assume a more or less moundy form. The three largest patches occur near Murton, at Damses Bridge south-west of Salutation Hall, and near Mount Pleasant. The two former are mostly gravel, but sand also occurs in the latter and may be seen in the railway-cutting. There are no good sections. The flat of gravel at Groathaugh in the S.W. may be an old river-terrace.

It may be as well to mention that in the north bank of the Tweed, opposite Yarrow Slacks, fragments of shells are found

in the boulder clay and in gravelly bands connected with it. The fragments may be seen strewn about near the paths in the wood between Castlehills and New Water Haugh where the ground is a mass of slips, but they have been traced to gravelly bands *in situ* at heights of from 75 to 90 feet above Ordnance datum. From a collection made by myself and one of my sons, the following list was drawn up by my colleague Mr. G. Sharman:—

Ostrea.
Pecten.
Astarte borealis?, *Chemn.*

— sp.
Cardium edule, *Linn.*
Saxicava rugosa, *Pennant.*
Mya truncata, *Linn.*
Tellina balthica, *Linn.*

Cyprina islandica, *Linn.*
Turritella terebra, *Linn.*
Littorina littorea, *Linn.*
Buccinum?.
Dentalium abyssorum?, *Sars.*
Fragments of *Belemnites*
(derived).

The only example of a striated surface noted in the district, occurs north of Murton where the sandstone is glaciated in an E.N.E. direction. Most of the sandstones are soft, so that striae would not long be retained, and the limestones which might better preserve them are seldom exposed.

POST-GLACIAL DEPOSITS.

These consist of the freshwater sand, loam, and gravel of the River Tweed and of several small burns; they include also the peat and stoneless grey clay of old tarns and marshes, and the tidal mud of the mouth of the Tweed, which is marine. The latter deposit is scarcely noticeable except at Yarrow Slacks.

The number of old tarns must have been great at one time, and some of them, now mostly filled with peat, are of considerable size, as for instance the one north of Thornton, which is divided into Thornton Bog, Longridge Bog, and Murton Craggy Bog. The bog north of Felkington Moor and Shoreswood Bog are also of good size. Of the old tarns now filled with grey clay may be mentioned the one south-east of East Ord and the one east of Grievestead. In the latter, 18 inches of stiff grey clay overlies sand.

Along the course of the Tweed there are in several places well-marked gravel-terraces at great heights above the present Alluvial flats or highest flood-marks of the river. Thus at Yarrow Haugh there are three distinct Alluvial flats, one above another, and at Lowhouse the same number, the highest being about 50 feet above the river. Between Horncliffe and Norham there are only two terraces, the highest being below the 50-foot contour. At Norham they are most numerous and form extensive spreads of gravel the highest being about 50 feet above the river. West of Newbiggin there are only two certain terraces, with the doubtful gravel-flat of Groathauigh previously mentioned.

APPENDIX.

I.—LIST OF FOSSILS.

Fossils from the Tuedian Beds.

Named by Mr. G. Sharman.

The following is a list of the localities from which specimens have been obtained; the numbers corresponding with those appended to the names of species:—

1. Newbiggin Burn, 100 yards above junction with Tweed and one mile south of Norham.
2. River Tweed, 100 yards below Norham Castle.
3. River Tweed, half a mile below Norham Castle.
4. Horncliffe Dean, near mill, south of Horncliffe village.
5. River Tweed, one mile below West Ord, and near point marked 105·8 on the 6-inch map, Sheet III.

PLANTÆ.

Plant-remains, 3, 4.

Cardiocarpus nervosus, *Kidston*, 4.

Alcicornopteris convoluta, *Kidston*, 2, 4.

ANNELIDA.

Spirorbis helicteres, *Salt*, 3.

OSTRACODA.

Leperditia, 2.

MOLLUSCA.

Murchisonia elongata?, *Portl.*, 3.

Natica, 3.

Orthoceras, 3.

PISCES.

Strepsodus (Archichthys) Portlocki, *Ag.*, 3.

Callopristodus (Ctenoptychins) pectinatus, *Ag.*, 2, 3.

Fish bones, 3, 5.

— tooth, 4, 5.

Gyracanthus, 3.

Palæoniscoid scale, 3.

Psammodus?, 3.

Rhizodopsis, 1.

In the *Transactions of the Berwickshire Naturalists Club*, vol. ii. p. 168 (1846), at the Norham meeting, we find the following: "Some very fine fossil trees similar to those found at Lennel some years ago, were inspected at the vicarage on our return; they were dug out of the sandstone cliff where the new and hideous bridge is erected."

In vol. v. of the same *Transactions*, p. 187 (1865), at another meeting at Norham, it is stated that, up the river, teeth and scales of *Rhizodus Hibberti* and other ganoid fishes were discovered, with the remains of *Lepidodendron* and other plants. Worm-tracks and borings are also mentioned.

For fossils of the Calcareous Division reference may be made to the lists in the Memoir on 110 S.W. already published, and to those in the forthcoming Memoirs on 110 N.E. and 110 S.E. The sections of the Limestones in this district are poor, and fossils cannot readily be obtained.

II.—LIST OF CHIEF PUBLICATIONS ON THE GEOLOGY OF THE DISTRICT.

1831.

WINCH, N. J.—Remarks on the Geology of the Banks of the Tweed. *Trans. Nat. Hist. Soc. Northumberland, Durham, and Newcastle*, vol. i.; also 4to. Newcastle; and *Phil. Mag. and Ann.*, new series, vol. i.

1833.

WITHAM, H.—On the Red Sandstones of Berwickshire. *Trans. Nat. Hist. Soc. Northumb., Durham, and Newcastle*, vol. i.

1835.

MILNE, D.—On the Geology of Berwickshire. *Rep. Brit. Assoc. for 1834*, Sect., p. 624; *Trans. Highland Soc.*, vol. xii. p. 169; and *Quart. Journ. Agric.*, vol. vi. p. 182. Published separately as a pamphlet, in 1837, entitled "A Geological Survey of Berwickshire."

1838.

MILNE, D.—On the Berwick and North Durham Coalfield. *Rep. Brit. Assoc. for 1839*, Sect., p. 76.

WOOD, N.—On the Red Sandstone of the Tweed and Carlisle. *Ibid.*, p. 78.

1861.

BOYD, E. F.—On a Part of the Carboniferous or Mountain Limestone Series of North Northumberland. *Trans. N. of Engl. Inst. Min. Eng.*, vol. ix. p. 185. (Discussion in vol. xi. pp. 174, 196. 1862.)

1867.

TATE, G.—Miscellanea Geologica. *Proc. Ber. Nat. Club*, vol. v. p. 283.

1868.

BAILES, G.—Sections of Mountain Limestone Strata at Scremerston, North Northumberland, with a "Note on the Scremerston Sections," by G. TATE. *Proc. Ber. Nat. Club*, vol. v. pp. 349–57.

1876.

MILNE HOME, D.—Notices of High Water Marks on the Banks of the River Tweed and some of its Tributaries, &c. *Trans. Roy. Soc. Edin.*, vol. xxvii. p. 513.

1884.

GUNN, W.—On the Finding of Shells in the Boulder Clay near Berwick-on-Tweed. *Proc. Ber. Nat. Club*, vol. x. p. 540.

1896.

GUNN, W., and C. T. CLOUGH.—The Geology of the Country between Wooler and Coldstream. 8vo. London. Geological Survey Explanation of Quarter-sheet, 110 S.W. (New series, Sheet 3.) A longer list of papers on North Northumberland will be found in the Appendix to this publication.

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